4 HAZARD SPECIFIC DISCUSSION

This section describes, using figures and text, the chemical and radiological hazards associated with LANL operations, past, present, and future. The eight watersheds named in Section 1.3 of this document are represented as "hazard areas." There are two maps for each hazard area, one representing the current state (i.e., 2003) and another representing the projected end state 20 years after completing the EM mission (i.e., 2035). For each map, there is an associated conceptual site exposure model. The conceptual models describe the release, transport, and potential exposure pathways for each of the hazard categories (A, B, or C) present within each hazard area. Hazard categories share a common fate in the environment, and have a potential for impacting a common receptor. The descriptions of affected media and transport and exposure pathways provided in Table 3.5-1 apply to all of the conceptual site exposure models in this section, as do the controls identified in the conceptual site-wide exposure model for the current state and the risk-based end state (cf Figures 3.5b1 and 3.5b2).

Aerial orthophotographs for each hazard area are also presented. These are present to aid in the understanding of surface hydrology and geology/topography.

Using a LANDSAT image, Figure 4.0.1 provides a frame of reference for the individual hazard-area maps that follow. This map assigns each watershed a number corresponding to the order in which they are discussed in the following subsections. It also gives a sense of the site-wide morphology, which plays an important role in the transport and fate of contaminants in the environment. (Note that the order of presentation does not correspond with the order of priority discussed in Section 1.)

4.1 Hazard Area 1: Los Alamos/Pueblo Watershed

The Los Alamos/Pueblo watershed (identified as 1 on Figure 4.0.1) covers a significant portion of the northern LANL area, extending from the western to the eastern borders. It is an east trending canyon that originates on US Forest Service land at an elevation of 9950 ft asl. The drainage extends about 16 mi from the headwaters to its confluence with the Rio Grande at an elevation of 5550 ft asl, and has a drainage area of about 17.5 mi^2. This drainage crosses San Ildefonso Pueblo land for about 3.5 mi before joining the Rio Grande. The canyon passes through or is adjacent to several of LANL's Technical Areas.

The watershed is 600 to 3000 ft wide at the top and varies in depth from 200 to 800 ft. It cuts into Bandelier Tuff across LANL property, and into the Puye Formation before it reaches the Rio Grande. The canyon floors are relatively flat, are filled with alluvium and colluvial soils eroded from the canyon walls, and vary in width from a few tens of feet to 2000 ft. The sides of these canyons are steep and rocky, and are partially covered by trees, particularly on the south sides (the north-facing slopes).

On a regional scale, Los Alamos/Pueblo watershed is an interrupted stream characterized by extremely variable flow. Two springs in the uppermost reaches of the watershed support a perennial reach to within a few to several hundred yards. On LANL property, surface water flow is mainly ephemeral above the Los Alamos County Sewage Treatment Plant, which typically supports surface flow to the eastern LANL boundary. Two springs just east of the boundary, and one spring in the lower canyon, flow intermittently and provide surface water to the stream and saturation in the alluvium. Springs, effluent flow, and precipitation, combined with seasonally variable saturated alluvial conditions in the lower canyon can support surface flow to the Rio Grande several days of the year.

4.1.1 Current State

The current state of hazards, hazard controls, and exposure controls in the Los Alamos/Pueblo watershed are described in this section. For clarity, the Hazard Categories defined in Section 3.5 are used. Hazard Category maps and associated conceptual site exposure models are both presented.

(Refer to Section 3.5.1 for detail on the general elements of the conceptual site exposure model.)

Figure 4.1a1 shows the existing airborne discharges (Hazard Category A) within Los Alamos/Pueblo watershed, and the associated conceptual site exposure model. Current airborne sources include exhaust emissions and open-air firing sites. The map shows wind roses, which indicate the predominant daytime and nighttime wind directions, hence the dominant directions of airborne dispersion. The map

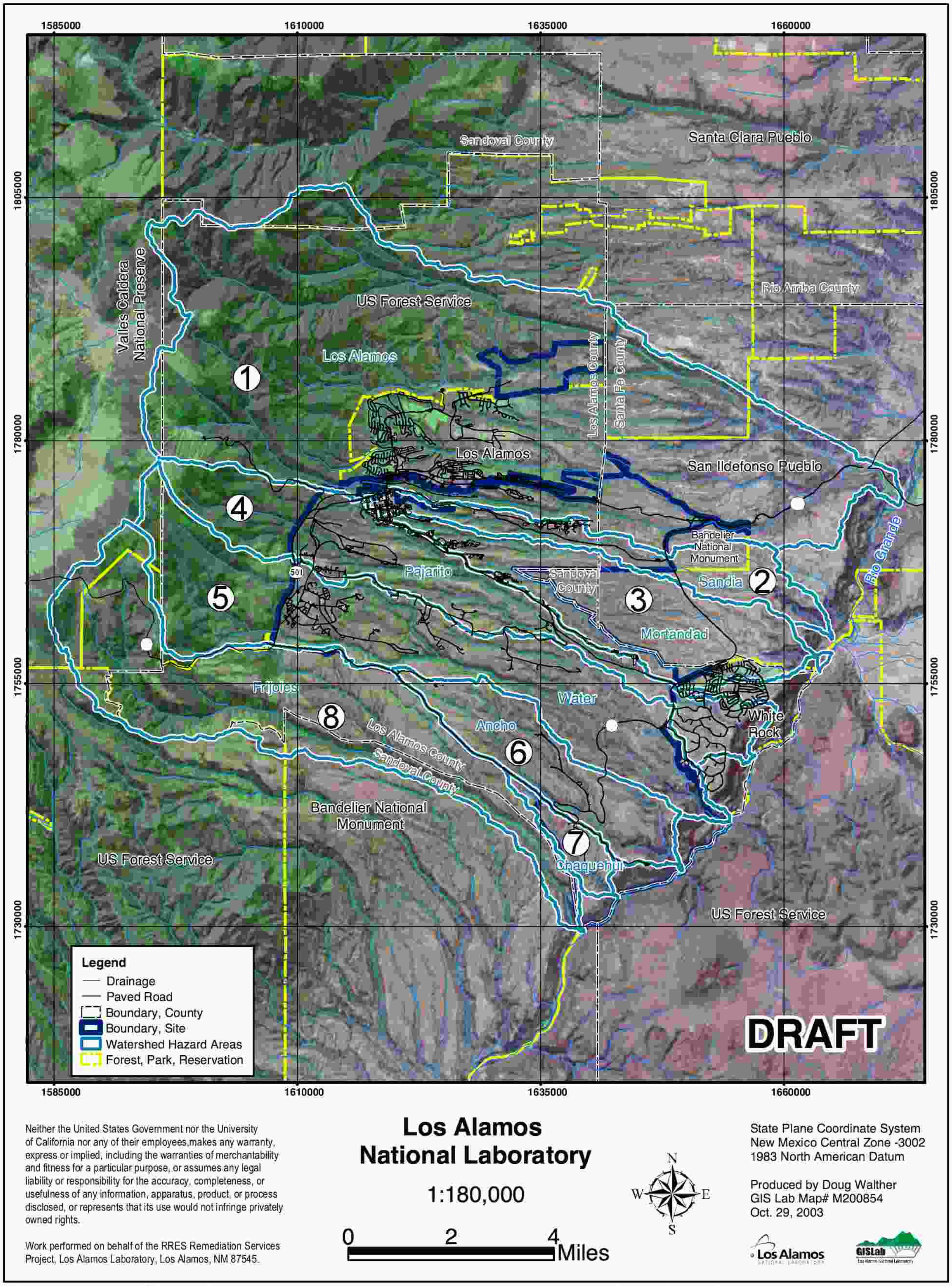
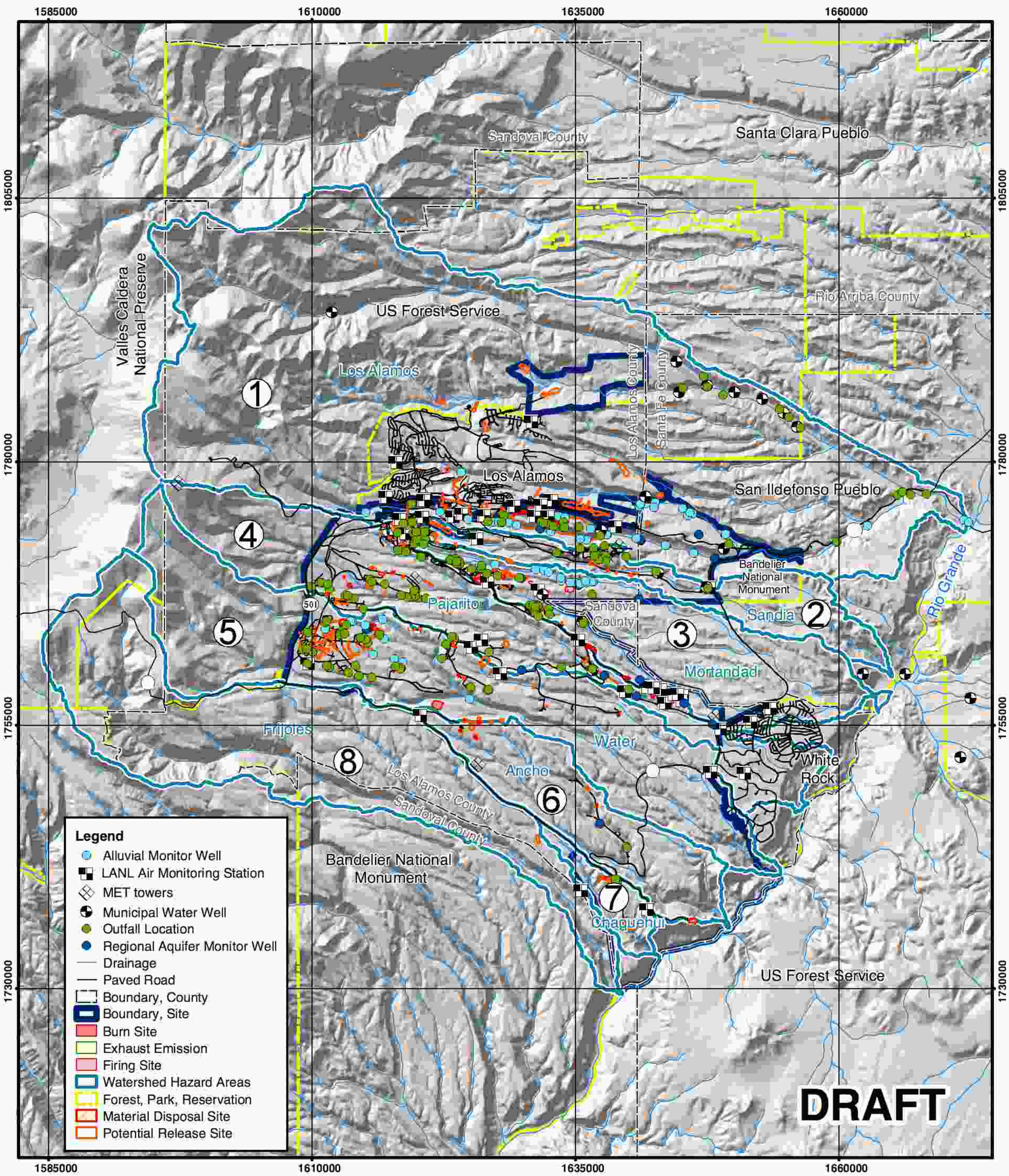


Figure 4.0.1. Site-wide hazard map Landsat photo and surface interface.



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Work performed on behalf of the RRES Remediation Services Project, Los Alamos Laboratory, Los Alamos, NM 87545.

Los Alamos National Laboratory

1:180,000

0 2 4 Miles

N W E S

State Plane Coordinate System
New Mexico Central Zone -3002
1983 North American Datum

Produced by Doug Walther
GIS Lab Map# M200806
Oct. 27, 2003

Los Alamos NATIONAL LABORATORY
GISLab Los Alamos National Laboratory

Figure 4.0a. Site-wide hazard map, Current state.

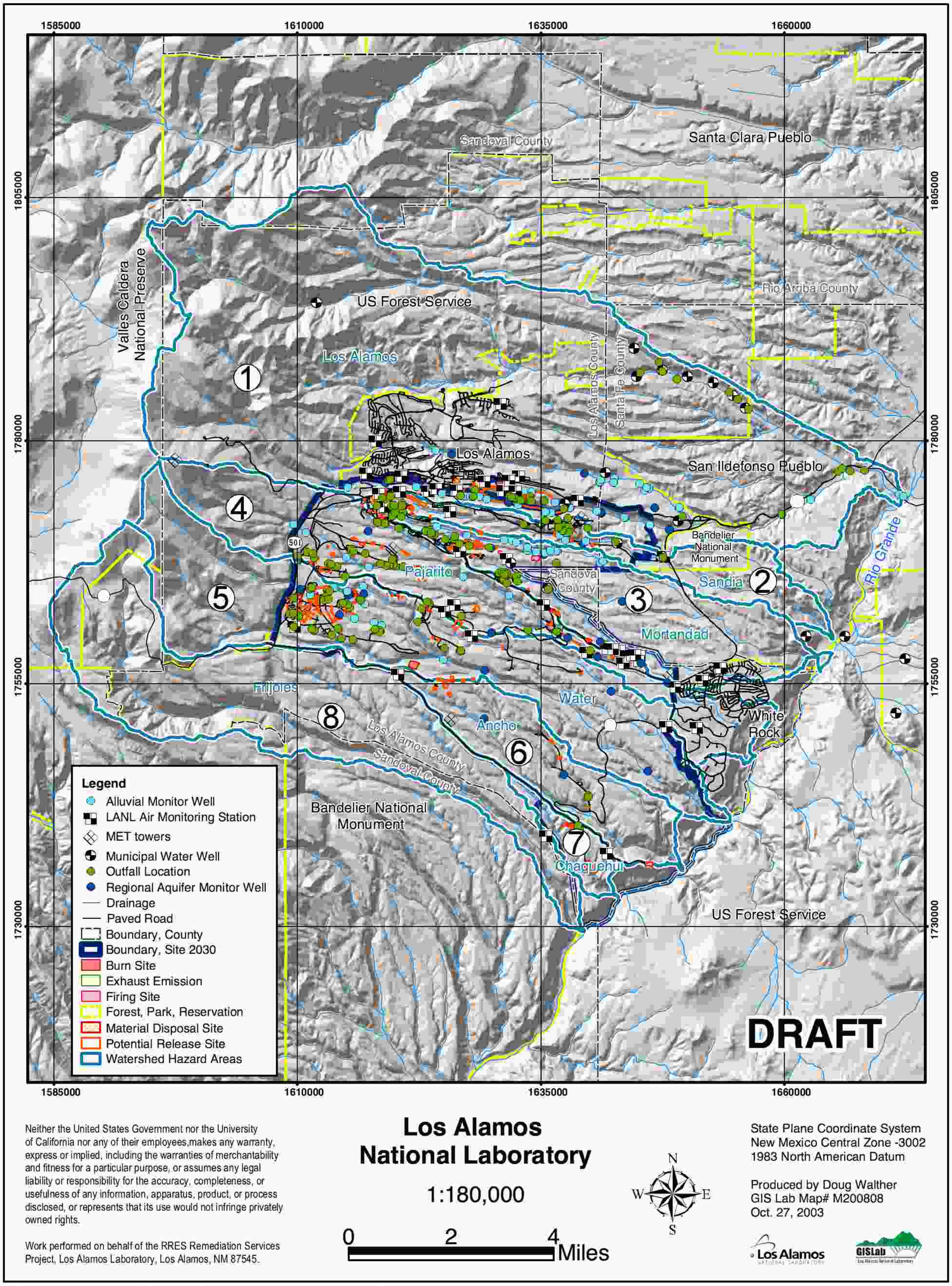


Figure 4.0b. Site-wide hazard map, End state.

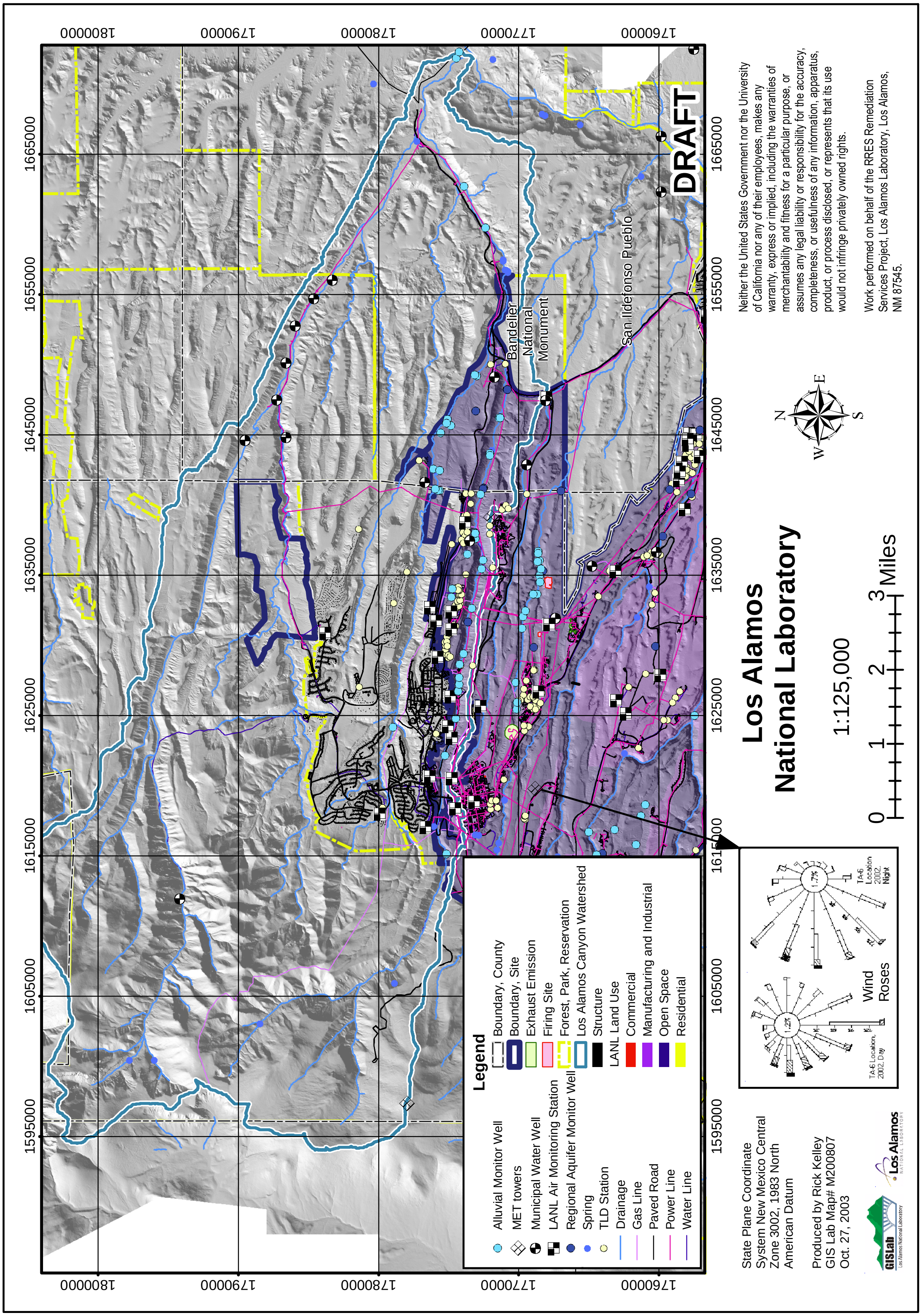
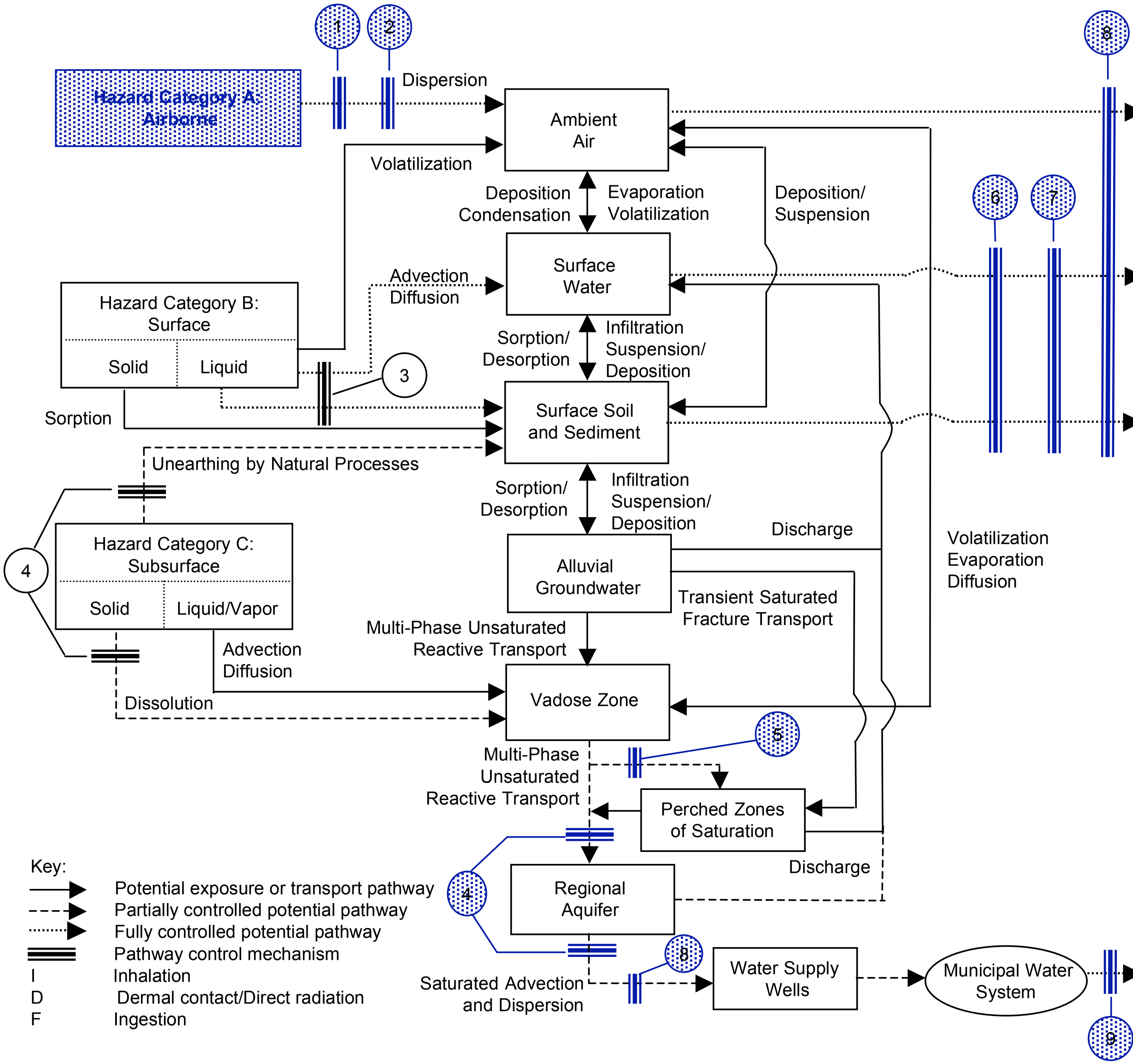


Figure 4.1a1. Hazard Area 1: Los Alamos Canyon Watershed, Hazard Category A: airborne releases, Current state.

Hazard Category A Conceptual Site Exposure Model– Current State



Potential Exposures

Occupational	Recreational Onsite	Recreational Offsite	Residential	Ecological
I/D	I/D	I/D	I/D	I/D
D/F	D/F	D/F		D/F
I/D/F	I/D/F	I/D/F	I/D/F	I/D/F
D/F			D/F	

also identifies LANL's air monitoring stations and thermoluminescent radiation detectors (TLDs). The conceptual site exposure model highlights the existing pathway controls for potential exposures to airborne contamination.

Hazard Category B represents surface legacy contamination on mesa tops, canyon slopes, and within canyons as a result of permitted operational discharges directly into portions of the watershed, and as a result of surface-water and airborne transport of contamination from legacy sources within the watershed. Figure 4.1a2 identifies the current surface contamination sources, which are dominated by outfalls from operational facilities. Potential release sites in this category are also shown, as are the environmental monitoring stations. The associated conceptual site exposure model identifies the existing controls relevant to controlling exposures to surface releases. Exposures to contaminated media under current conditions are controlled by natural processes that attenuate contaminant concentrations as a function of distance from their sources, and by institutional and administrative controls.

Characterization of contaminated surface and alluvial materials is systematically conducted in accordance with a physical geomorphology model. The Los Alamos/Pueblo watershed geomorphology model is considered representative of the range of features, events, and processes occurring in the other watersheds of the Pajarito Plateau.

Based on the geomorphology model and data collected to date, sediment transport by surface water is judged to be the predominant mechanism for redistributing contaminants into and within canyons comprising the Los Alamos/Pueblo watershed. The present inventory of contaminants in canyons is dominated by secondary contamination from legacy liquid discharge sources, which subsequently adsorbed onto relatively fine-grained sediment particles. While secondary contamination transported into canyons mainly bind to the sediments, more soluble contaminants remain in solution. Larger particles such as shrapnel dispersed from explosives testing can be transported as particles on the streambed.

Sediment transport occurs during floods, snowmelt events, and sustained releases from outfalls. The largest floods, and therefore the largest potential for sediment redistribution, are caused by summer thunderstorms. Sediment transported by these flows is either redeposited downstream at various locations or transported to the Rio Grande. One effect of continued sediment transport over time is to decrease the total inventory of contaminants in some upstream areas and increase the inventory in some downstream areas.

Sediments and associated contaminants deposited in different geomorphic locations, such as active channels, inactive channels, and floodplains or low terraces, remain in place for varying lengths of time. Transport of sediments in active channels can occur during relatively frequent, moderate-sized storm or snowmelt flows, whereas transport of sediments currently residing in floodplains and low terraces requires infrequent large floods during which the stream channel can erode laterally. Contaminants in floodplains and low terraces may remain in storage for decades or longer.

Groundwater transport of contaminants in sediment or bedrock, under both saturated and unsaturated flow conditions, is considered a potential transport pathway in the Los Alamos/Pueblo watershed. Groundwater in unsaturated zones is considered to be a transport pathway between saturated zones, not an exposure pathway. Water in these zones is not sufficient in either quantity or continuity to provide a reliable drinking water source for humans.

Contaminants will migrate laterally down the canyon through the alluvium in interaction with the surface water. Groundwater from the alluvium may be an important source of recharge for intermediate perched zones. Relatively rapid infiltration may be occurring beneath the alluvium in the downstream reaches of Los Alamos/Pueblo watershed by unsaturated flow through the porous matrix of the Otowi Member of the Bandelier Tuff. Hydraulic interconnections between the alluvium and the intermediate perched zones are evidenced in Los Alamos/Pueblo watershed. There is also evidence of recharge between the alluvium and the regional aquifer in lower Los Alamos/Pueblo watershed, where the canyons cut into the Otowi Member of the Bandelier Tuff.

Groundwater in the alluvium has historically had the highest concentrations of contaminants of any groundwaters in the area. Groundwater within the intermediate perched zones generally contains lower concentrations of the known contaminants. Groundwater in the regional aquifer generally appears to be uncontaminated.

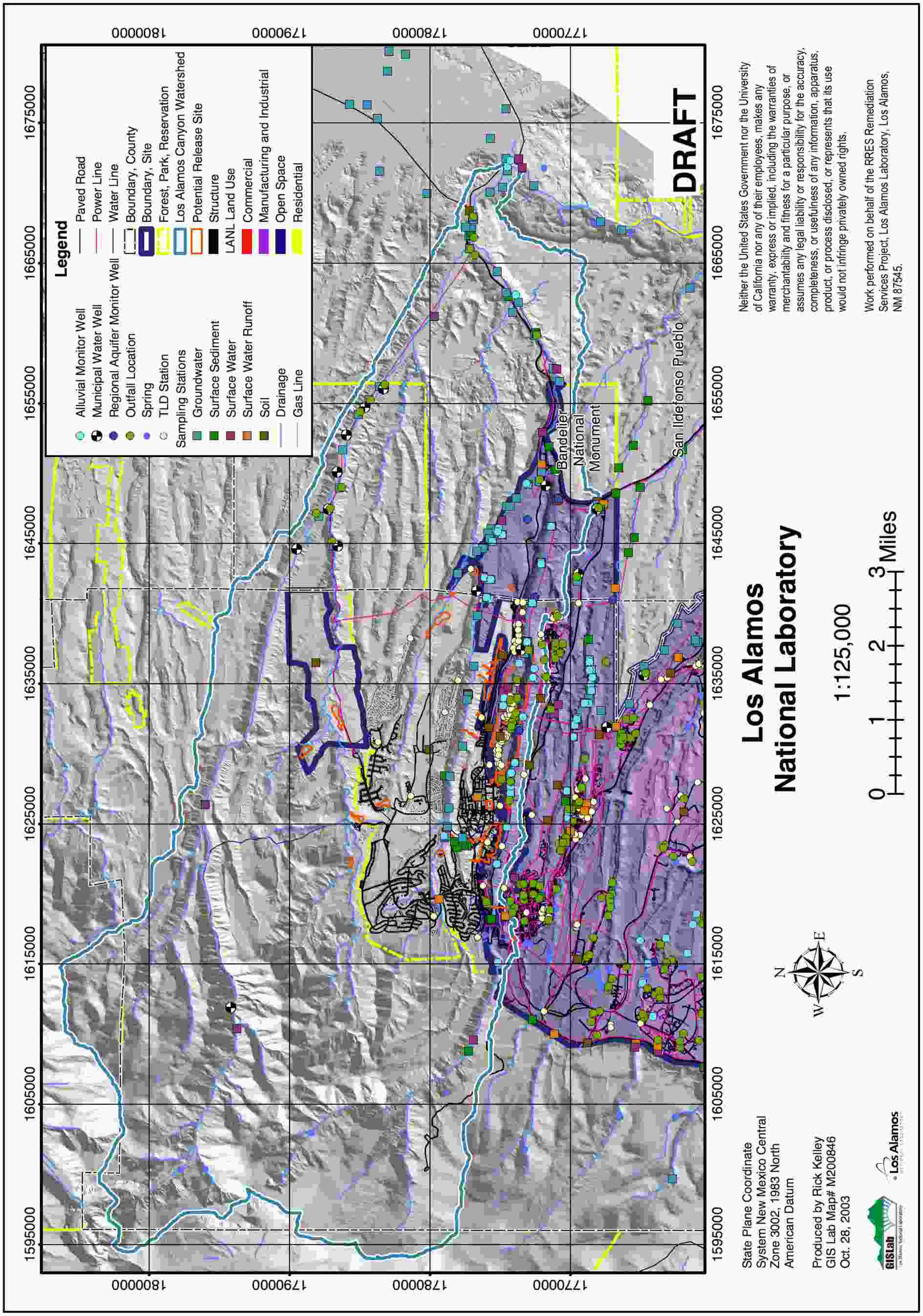
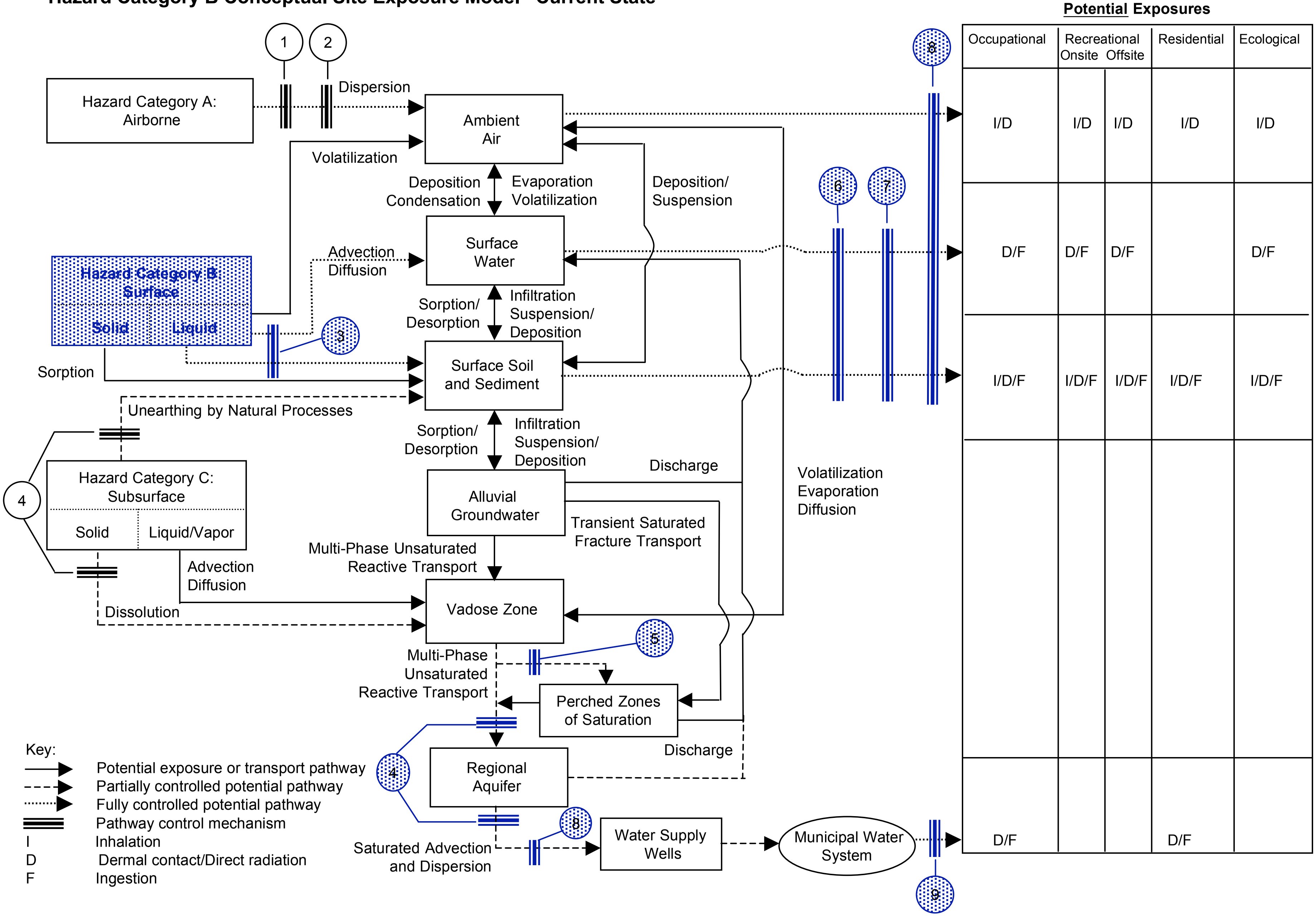


Figure 4.1a2. Hazard Area 1: Los Alamos Canyon Watershed, Hazard Category B: surface releases, Current state.

Hazard Category B Conceptual Site Exposure Model– Current State



Hazard Category C represents primary sources of contamination in the subsurface. In the Los Alamos/Pueblo watershed, there are five MDAs within Hazard Category C. All five are located on the mesa where the most intensive nuclear materials processing operations were conducted into the 1970s. With the exception of MDA B, all of the MDAs are located near facilities that are still used by LANL, where perimeter fencing controls access. Radiological hazards signs are posted where the MDAs are located. MDA B is located across the street from a light industrial/commercial section of the town of Los Alamos, and is adjacent to a parking lot. MDA B is surrounded by a fence and posted to prevent access. The MDAs are capped with native materials (crushed tuff) and vegetation (primarily grasses).

Figure 4.1a3 identifies the MDAs comprising Hazard Category C in the Los Alamos/Pueblo watershed, along with other contextual features related to the control of potential exposures to these hazards. The associated conceptual site exposure model identifies the existing natural, engineered and institutional controls that control exposures to hazards MDAs. The following paragraphs summarize the current state of each MDA, and provide information relevant to the controls included in the conceptual site exposure model.

MDA A

MDA A was used for waste disposal during two periods, 1945-1949 and 1969-1977. Between 1944 and 1947, two shallow pits approximately 4 m (13 ft) deep received about 1020 m3 (36,000 ft3) of “solid wastes with alpha contamination accompanied by small amounts of beta and gamma.” (Rogers 1977, 0216) During this period, two underground storage tanks (the General’s Tanks) were installed to store a total of 49,000 gal. (186,200 l) of a sodium hydroxide solution, which contained 334 g (0.7 lb.) of plutonium-239 at the time of emplacement (circa 1947). The liquid from these tanks was recovered, treated, and solidified in cement in 1975. The contaminated cement remained buried at MDA A for several years, but was retrieved in the late 1980s and moved to MDA G. In 1969, a 9-m- (30-ft-) deep pit was excavated at MDA A for the disposal of building debris contaminated by uranium-235, plutonium-238, and plutonium-239 from nearby demolition work.

MDA B

MDA B was active from 1945 through 1948. A geophysical survey conducted in 1998 identified two disposal trenches approximately 15 ft (4.5 m) wide by 300 ft (90 m) long by 12 ft (3.6 m) deep and unlined, containing roughly 21,240 m3 (27,612 yd3) of waste. The radiological inventory includes “plutonium, polonium, uranium, americium, curium, lanthanum, (and) actinium.” (Rogers 1977, 0216) The disposal capacity of the pits is estimated to be about 21,000 m3 (760,000 ft3). The entire pit area is estimated to contain no more than 100 g (6.13 Ci) of plutonium-239. In 1984, portions of MDA B were resurfaced with a variety of cover systems as a pilot study conducted for DOE. These applications are still in place, all having about 3-ft- (1 m) crushed-tuff cover, which is placed over the original crushed-tuff cover. Variations include cobble and gravel biological barriers between the old and new covers, as well as shrub, grass, and gravel/mulch surface treatments. The total cover of this portion of MDA B is nominally 6.5-ft- (2 m) thick.

MDA T

MDA T received radioactively contaminated liquid from the plutonium processing laboratories between 1945 and 1952. In 1952, a liquid waste treatment plant was installed to remove plutonium and other radionuclides from process wastewater. Thereafter, the absorption beds received relatively small quantities of liquid waste until 1967, when a new liquid waste treatment process was initiated. Between 1968 and 1975, treated liquid waste was mixed with cement that was pumped into shafts at MDA T for disposal. After 1975, the cement paste was poured into corrugated metal pipes prior to emplacement in the subsurface, and retrievably placed at MDA T in 62 vertical shafts. Approximately 18,300,000 gallons (69,540,000 l) of liquid waste was discharged to the MDA T absorption beds between 1945 and 1967. “As of January 1973, the absorption beds contained . . .10 Ci of plutonium-239. . . As of July 1976, the disposal shafts contained 7 Ci of uranium-233, 47 Ci of plutonium-238, 3,761 Ci of americium-241, and 3 Ci of mixed fission products.” (Rogers 1977, 0216) The total volume of cement paste permanently disposed in shafts at MDA T was 122,500 ft^3 (36,750 m^3).

MDA U

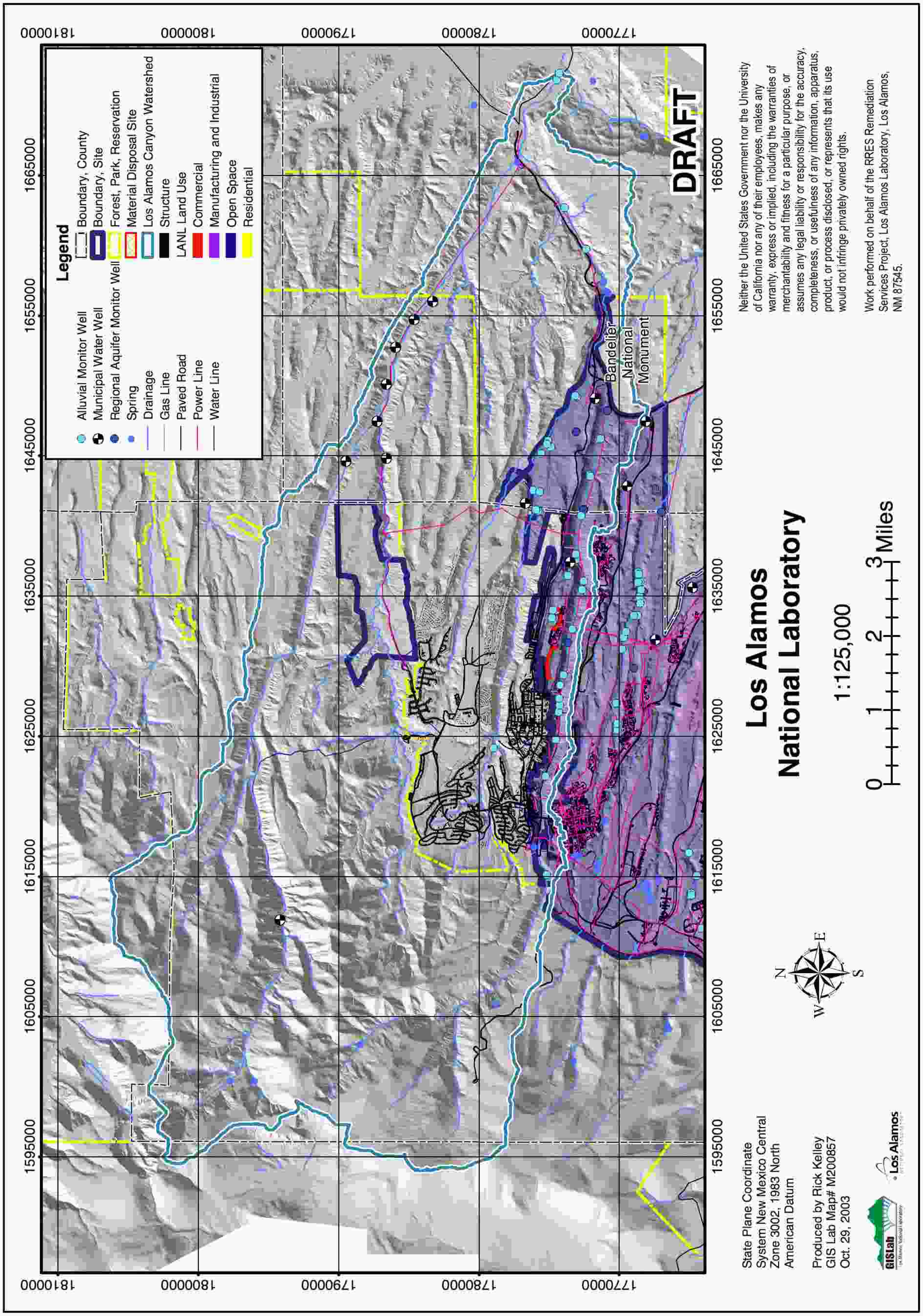
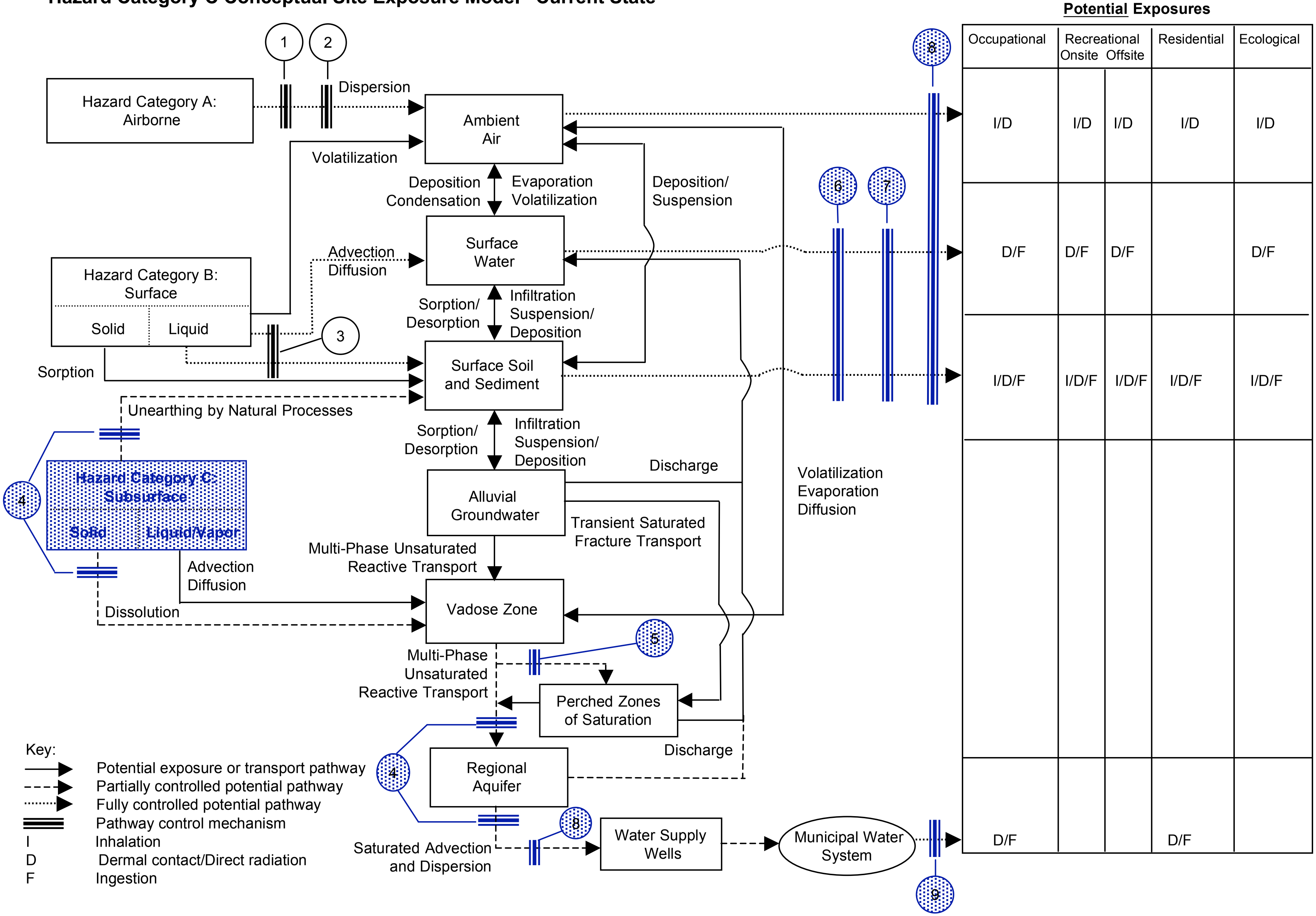


Figure 4.1a3. Hazard Area 1: Los Alamos Canyon Watershed, Hazard Category C: subsurface releases, Current state.

Hazard Category C Conceptual Site Exposure Model– Current State



MDA U absorption beds have a surface area of approximately 1800 ft^2 (162 m^2) and an estimated volume of about 18,000 ft^3 (540 m^3). They were used for subsurface disposal of radioactively contaminated liquid wastes from 1948 to 1968 (LANL 1991, 7529). The distribution box liquid-waste distribution systems were removed in 1985. Remaining is subsurface contamination bound to solid phases, covered by crushed tuff and native grasses. MDA U is fenced and posted as a radiological hazard.

MDA V

MDA V absorption beds occupy 15,000 ft^2 and have a volume of 4250 m^3 (5525 yd^3), used from 1945 through 1961 for liquid waste disposal from a laundry facility at TA-21-20. The laundry facility mainly washed clothing from uranium and plutonium refinement operations. A portion of MDA V was used recently for a successful demonstration of non-traditional in situ vitrification. The remainder of the site is covered with a vegetated crushed tuff cover.

The records of disposals summarized above were sufficient to provide bounding inventory estimates for radionuclides for the purposes of the MDA G composite analysis, which calculated the cumulative impacts of these MDAs at offsite receptor points defined in the MDA G performance assessment. The results of the composite analysis provides a first-order indication that multiphase unsaturated reactive transport processes naturally attenuate the groundwater-pathway risks posed by the hazards in MDAs A, B, C, T, U, and V.

Several studies of radionuclide transport beneath MDA T were conducted before the cleanup project was initiated. As a group, these studies indicate that radionuclides in liquid waste discharged directly into the Bandelier Tuff migrated to depths of hundreds of feet within the mesa, and also contaminated surface media. These results have not been refuted by investigations conducted in support of the cleanup project. Generalizing these results to MDAs U and V, which also received liquid waste, exposures are limited to direct contact with surface contamination. Such exposures are controlled by access restrictions and postings for radiological hazards.

4.1.2 Risk-Based End State

Figure 4.1b1 includes the anticipated risk-based end state to be achieved by remedial actions and institutional controls through 2035. Due to the small number of cleanup sites in Hazard Category A, and since LANL operations are not expected to change dramatically, few changes are visible on this map format. The conceptual site exposure model provides additional detail on the controls that are anticipated to achieve and maintain the risk-based end state relative to airborne releases.

Similar maps and associated conceptual site models are provided for the surface releases in Figure 4.1b2 and 4.1b3. The end states represented on these maps were discussed in Section 3. Risk-based decision analysis methods will be used to define cleanup goals for surface contamination and cap designs for MDAs. Cleanup goals will be consistent with industrial-use scenarios for locations within the LANL boundary identified as industrial use, and with recreational use scenarios for many of the canyons to be retained by LANL. Residential use scenarios will be used to support decisions for land tracts that may be transferred. The cap designs for the MDAs will be based on industrial-use scenarios, consistent with the planned land use. Monitoring of surface water and groundwater will also be based on risk-based decision analysis.

4.2 Hazard Area 2 – Sandia Watershed

The Sandia watershed heads on the plateau within the Laboratory boundary. It has a total drainage area of about 5.5 mi^2. The small drainage extends for about 10 mi across the central part of the LANL, and crosses San Ildefonso Pueblo land for about 3 mi before joining the Rio Grande.

The Sandia watershed is ephemeral to a point about 3 mi east of LANL's eastern boundary, where Sandia Spring supports perennial flow for a few hundred yards. This flow does not normally reach the Rio Grande. In the upper canyon, an effluent-supported reach arising from discharge of treated sanitary effluent supports a significant wetland and typically extends about 2.5 to 3 mi before infiltrating into the canyon bottom alluvium.

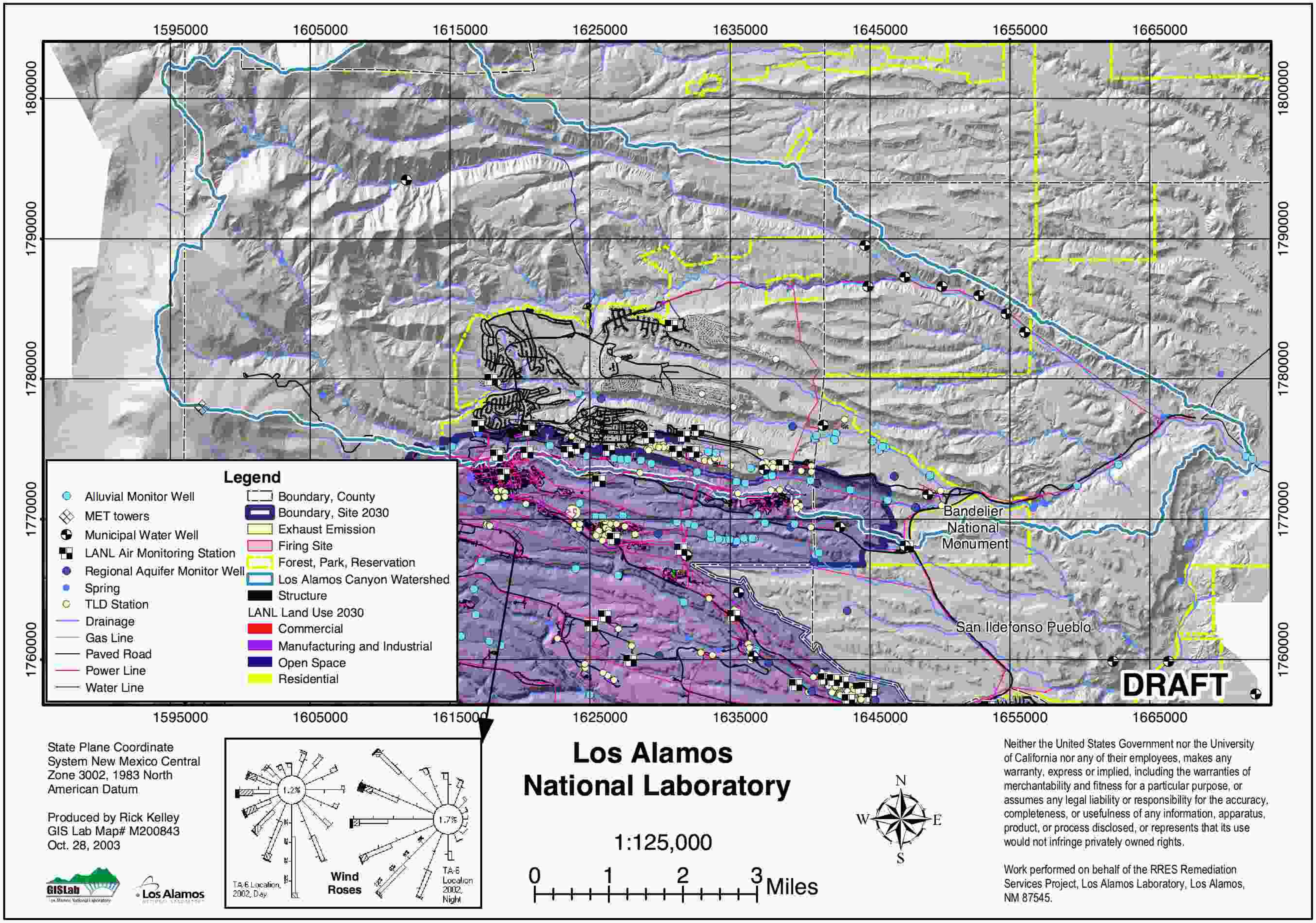


Figure 4.1b1. Hazard Area 1: Los Alamos Canyon Watershed, Hazard Category A: airborne releases, End state.

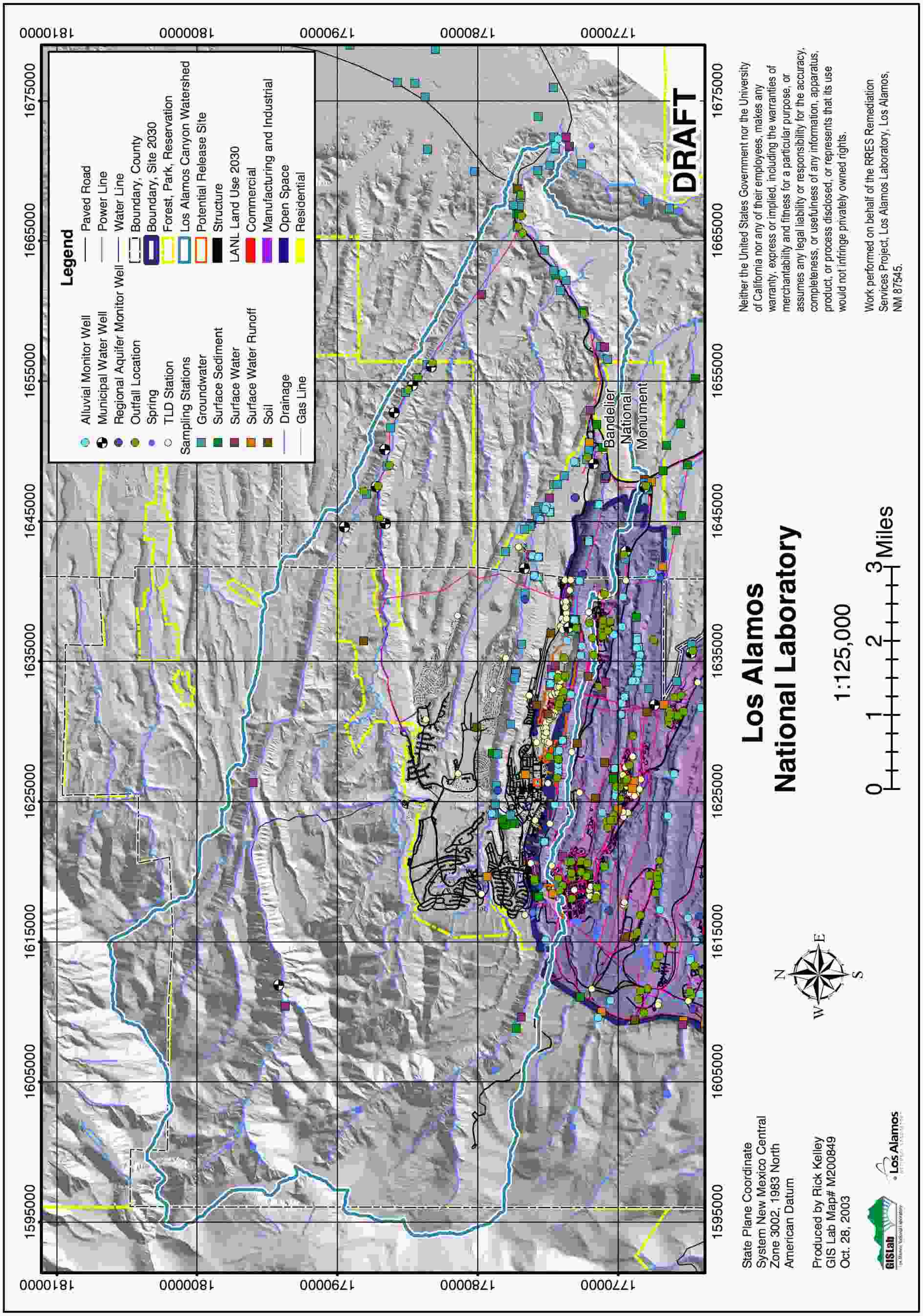


Figure 4.1b2. Hazard Area 1: Los Alamos Canyon Watershed, Hazard Category B: surface releases, End state.

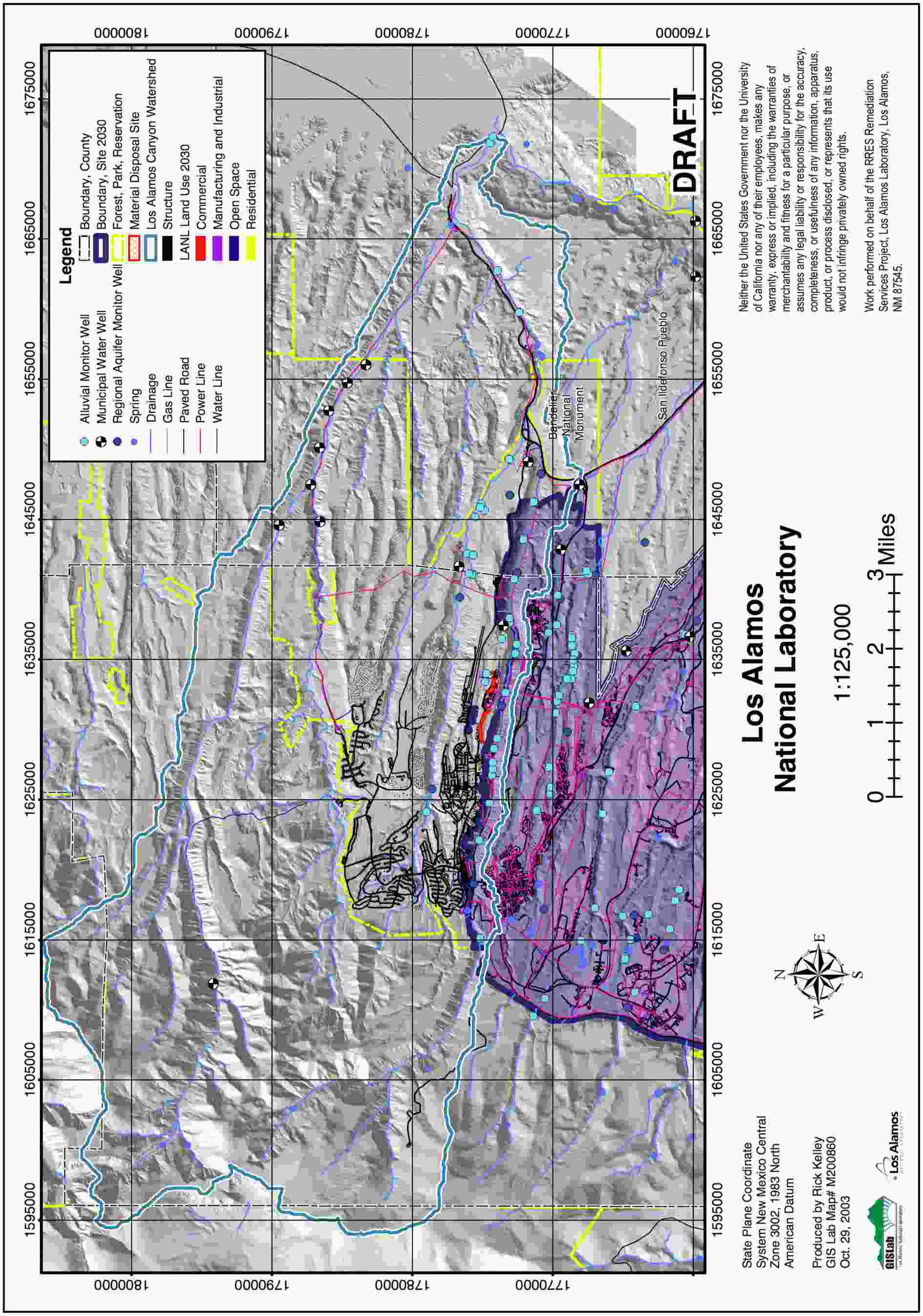


Figure 4.1b3. Hazard Area 1: Los Alamos Canyon Watershed, Hazard Category C: subsurface releases, End state.

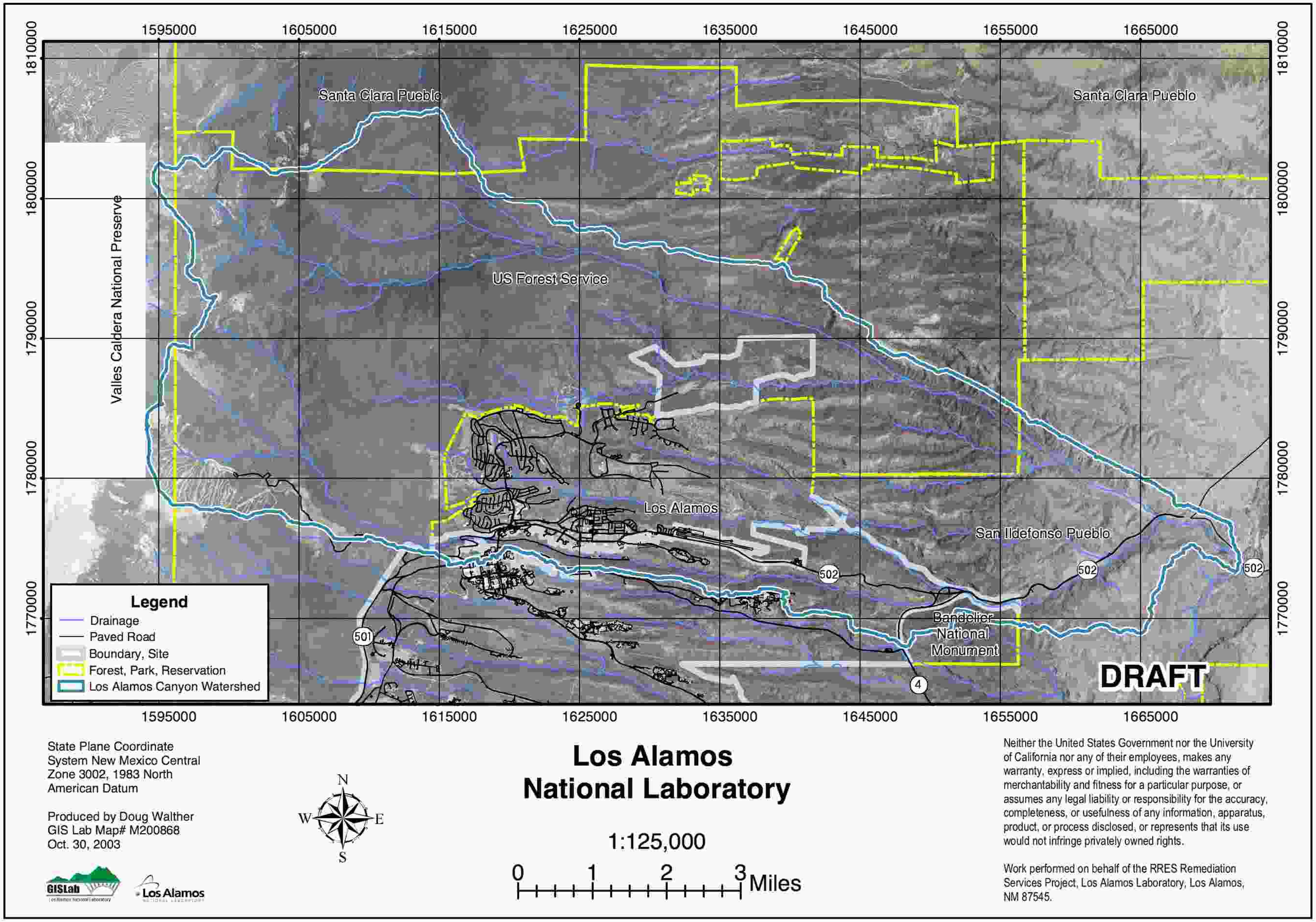
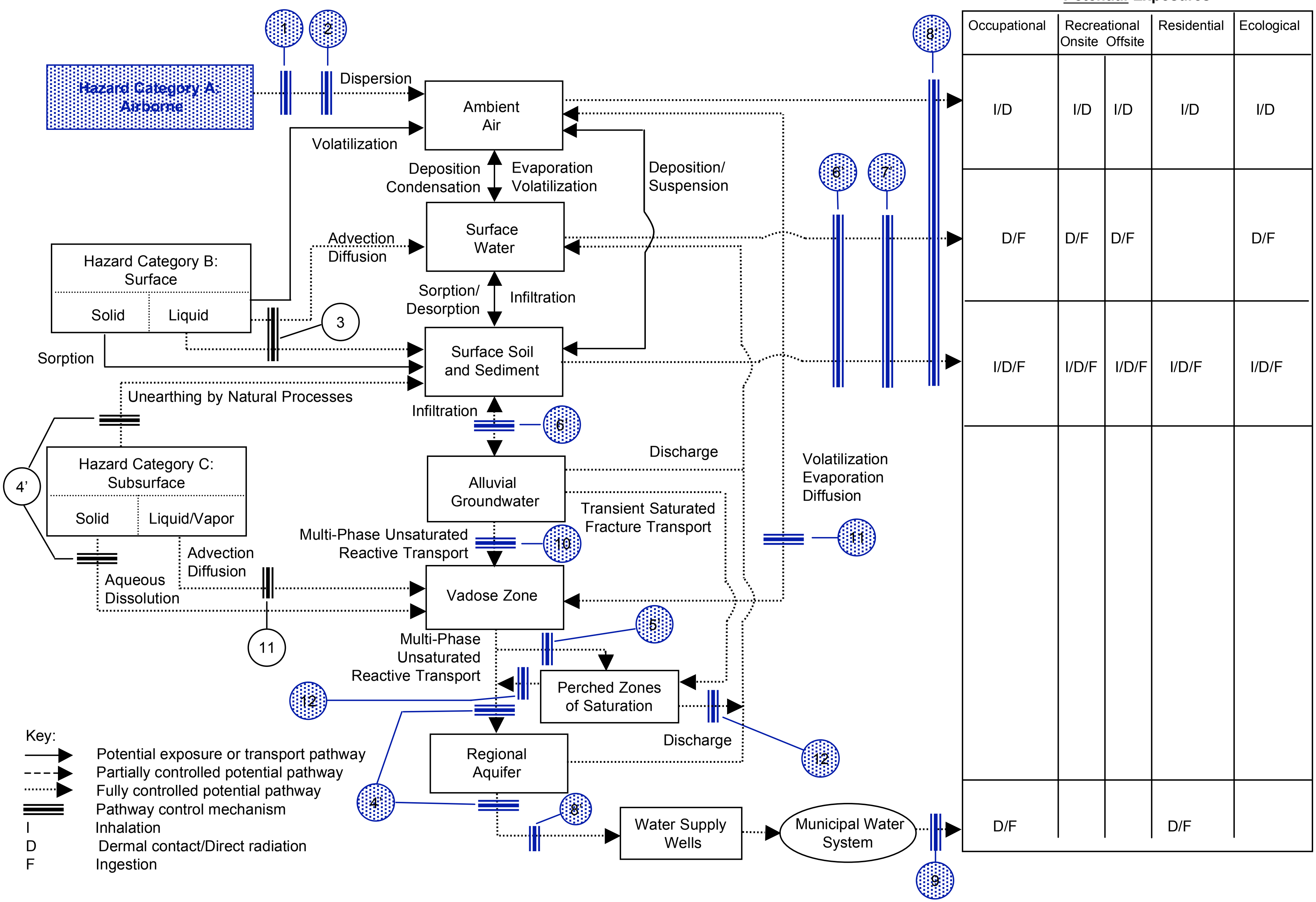
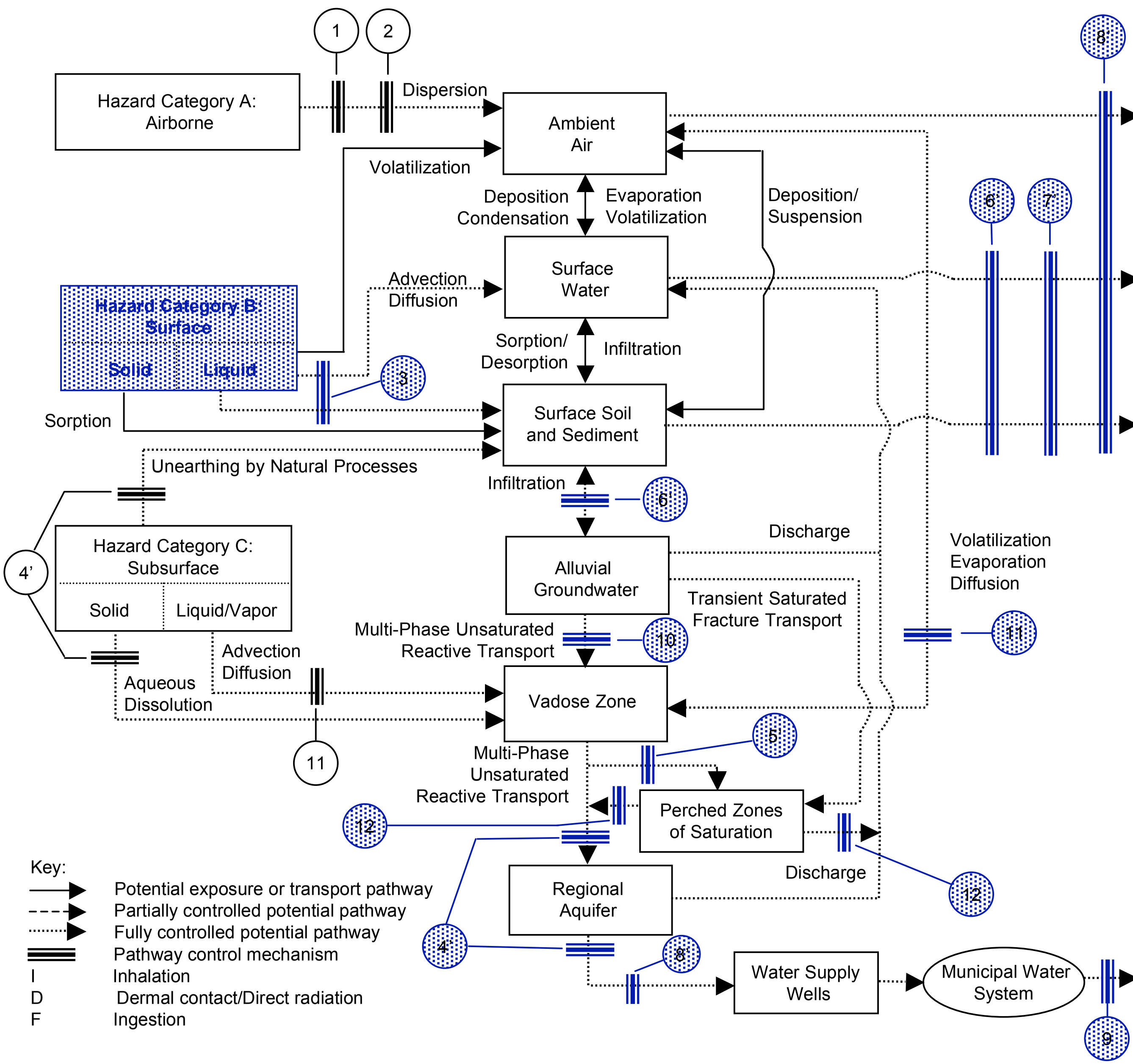


Figure 4.1a4. Hazard Area 1: Los Alamos Canyon Watershed orthophoto map.

Hazard Category A Conceptual Site Exposure Model– End State



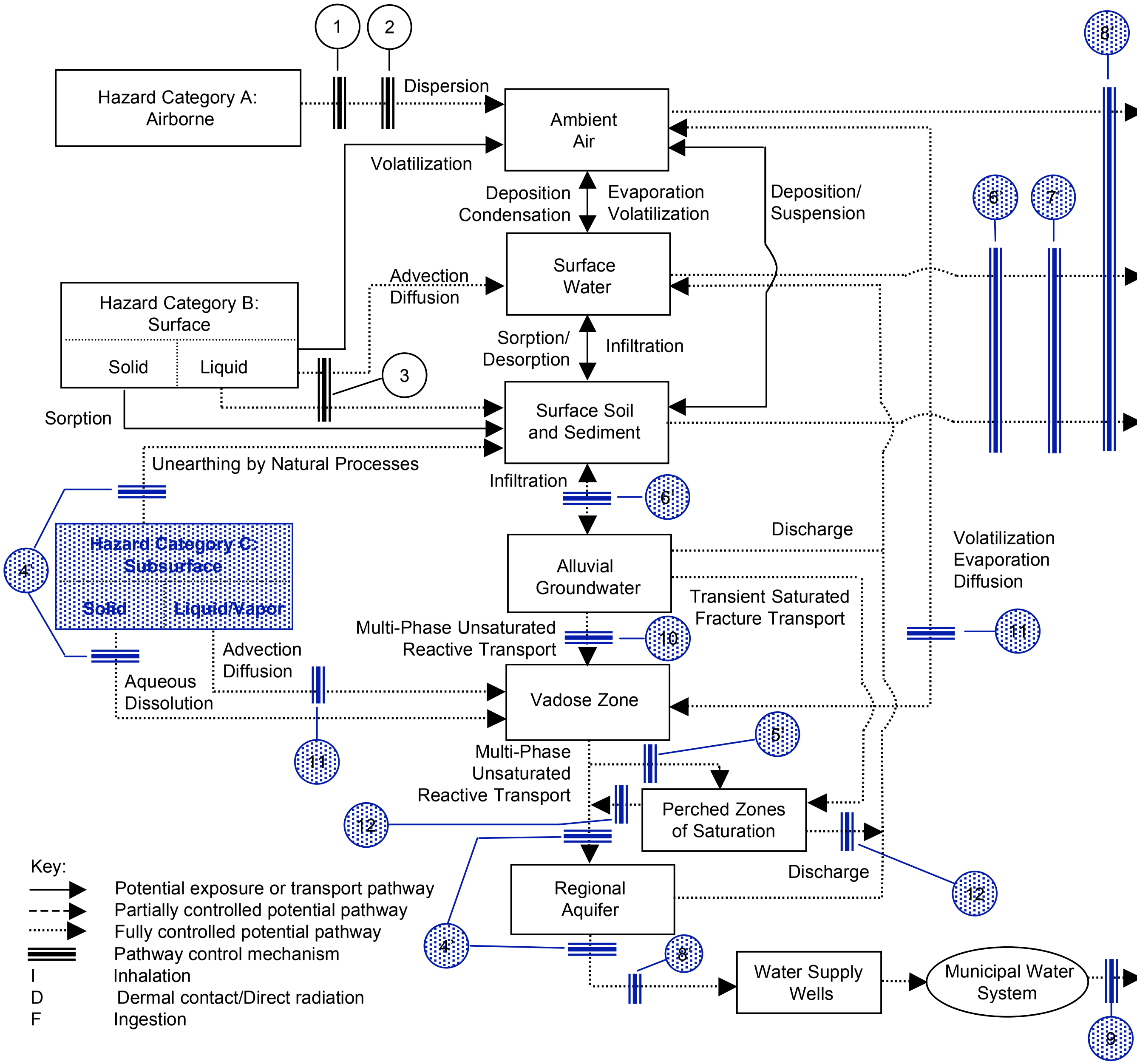
Hazard Category B Conceptual Site Exposure Model– End State



Potential Exposures

Occupational	Recreational Onsite	Recreational Offsite	Residential	Ecological
I/D	I/D	I/D	I/D	I/D
D/F	D/F	D/F		D/F
I/D/F	I/D/F	I/D/F	I/D/F	I/D/F
D/F			D/F	

Hazard Category C Conceptual Site Exposure Model– End State



Potential Exposures

Occupational	Recreational Onsite	Recreational Offsite	Residential	Ecological
I/D	I/D	I/D	I/D	I/D
D/F	D/F	D/F		D/F
I/D/F	I/D/F	I/D/F	I/D/F	I/D/F
D/F			D/F	